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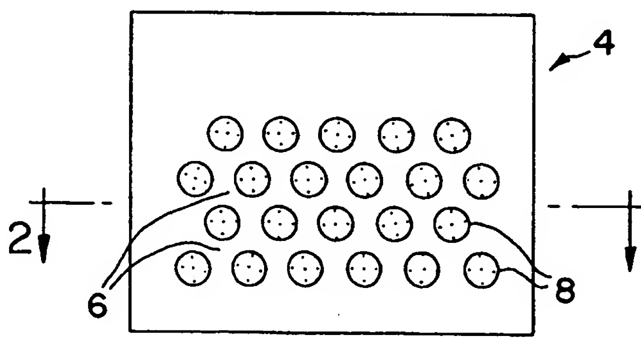


An ultralight nonwoven material useful as a facing fabric for forming various personal care products includes a nonwoven web having a fibrous structure of individual fibers or filaments and a basis weight of less than 0.40 ounces per square yard. A pattern of bonded areas is formed on the surface of the web, which has a dimensional stability characterized by a factor calculated by multiplying the nonwoven web's Poisson Ratio at 10 % elongation in the machine direction by the nonwoven web's basis weight, wherein said factor is equal to or less than 1.20 osy.PR. The bonded areas may be continuous or discontinuous.

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# ULTRALIGHT, CONVERTING FRIENDLY, NONWOVEN FABRIC

## Field of the Invention

The present invention relates to ultra-lightweight nonwoven fabrics that possess adequate strength and aesthetic properties to function as veneers, or facings, on clothlike laminates. The facings of the present invention may be used on absorbent personal care products, such as diapers.

## Background of the Invention

Lightweight nonwoven materials are often used to provide exterior facings on both absorbent and barrier laminate products. Examples of such nonwovens include spunbond, meltblown, and carded web nonwovens. Such webs may form the body-side facings on absorbent products, such as underpads and diapers. The facing performs the function of forming the inner coverstock for personal care products, such as diapers.

In a diaper, the facing is the liner that is disposed between the infant's skin and the diaper's absorbent material. As such, the liner's function is to be transparent to the fluids that are to be absorbed by the absorbent material so that the fluids are wicked away from the infant's skin as quickly as possible. These facings provide an abrasion-resistant, but clothlike, "veneer" on the absorbent material in these products. In addition, spunbond facings are used on products such as Kimberly-Clark's CREW®-brand clean room wipers. In these particular wipers, the absorbent properties are provided by a meltblown core, with the spunbond facing adding an abrasion-resistant and clothlike feel to the product.

Spunbond-meltblown-spunbond (SMS) barrier fabrics use spunbond facings to achieve the same function as facings in the CREW®-brand wipers. Carded or spunbond webs are often used in conjunction with film barriers to provide a clothlike veneer on the barrier. Examples of such film barriers include Mayo stand and back table covers for use in surgical procedures and outercovers for

personal care products.

The above-described facings are somewhat analogous to wood veneers used in making furniture. As in the production of veneer furniture, it is desirable from a cost standpoint to use as low a weight of veneer as possible. A further advantage of using less material in disposable products applications is the reduction of waste when such products are disposed.

Machines that produce personal care products, such as diapers, must process a plurality of continuous webs. Such processing is known in the industry as "converting". Large production lines of machines perform the conversion, which includes various operations such as registering the webs one on top of the other, joining the registered webs, gluing the registered webs, bonding the registered webs, and cutting the bonded webs into the desired product shapes. Such laminating processes may include the unwinding of the facing for overall bond lamination to another substrate, as in the case of production of SMS, or the unwinding into a product converting machine for peripheral bond lamination over the absorbent layer of a personal care product.

In the course of performing these various converting operations, the webs must be pulled and wound around rolls and otherwise subjected to stretching in both the machine direction (MD) and the cross-machine direction (CD). If one or more of the webs breaks during such processing, such breaking would tend to foul various stations of the machine and stop production until the fouling could be cleared and the machine restarted. Thus, the tensile strength of the webs used in such converting operations must be adequate to withstand such processing without continual breaking.

Moreover, each web must be able to undergo such stretching while still being maintained in registry with the other webs so that operations such as gluing, bonding and cutting may be properly performed to form a product that is aesthetically acceptable to the

consumer. Thus, the webs must have adequate dimensional stability to resist permanent deformation during processing. For example, the webs must have adequate dimensional stability to resist the tendency to "neck-in" as a web is stretched in the machine direction. Generally, fabrics that "neck-in" will distort to become longer in the machine direction and shorter in the cross-machine direction when they are converted into products.

As mentioned above, lightweight webs are desirable because they permit a reduction in the weight of the overall product and in the amount of material needed for the facing, thus reducing the cost of the overall product. While lighter weights are desirable, known clothlike nonwovens lose dimensional stability as their weight is reduced. In particular, they tend to neck-in in the cross machine direction when being unwound and drawn during converting processes. This tendency of the facing to neck-in creates a difficult process to control, especially in achieving the desired width of the facing of the finished laminate.

One solution to the neck-in problem has been to increase the degree of bonding in the facing. Another potential solution is to change from the typical point bonding to overall fiber interbonding. Nylon spunbond (Cerex®) and polyester spunbond (Reemay®) are available in light weights and are dimensionally stable. In these products, the bonding generally occurs at each fiber-to-fiber contact point, thus providing dimensional stability. A polyolefin spunbond material available from AMOCO also has these characteristics. While achieving the required dimensional stability, these materials do not have the surface fiber mobility that is need to impart the clothlike feel which is desirable for most personal care product facings.

Heretofore, the above-noted requirements of tensile strength and dimensional stability have prevented the use of webs lighter than about 0.40 ounces per square yard (osy) for facings. Webs that are lighter than 0.40 osy, often lack the required tensile strength and/or

dimensional stability and thus are not considered "converter friendly." Webs that are not converter friendly may be utilized in currently commercial products, but their dimensional stabilities are insufficient to allow them to be converted into products without substantial waste production and down time in the converting process itself.

## Objects and Summary of the Invention

It is an object of the present invention to provide a light weight non-woven material which may be utilized to form the facing.

It is another object of the present invention to provide a personal care product or other product such as a laminate with a facing formed of a light weight non-woven material.

It is a further object of the present invention to provide an ultra lightweight non-woven material having a basis weight less than about 0.40 osy and which is suitable to form the facing of a personal care product or other product such as a laminate.

Additional objects and advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

To achieve the objects and in accordance with the purpose of the invention, as embodied and broadly described herein, an ultralight nonwoven web is provided and exhibits a dimensional stability comparable to that of heavier fabrics. The superlightweight nonwoven facing that resists neck-in during lamination or converting provides a surface fiber mobility that results in a material having a clothlike feel. The facing may be wettable for use in absorbent products or non-wettable for use in barrier products.

Specifically, the invention is directed to a nonwoven web that has a basis weight of less than 0.40 ounces per square yard (osy) and which uses either a continuous bonding pattern or a high density

discontinuous bonding pattern. The continuous bonding pattern results from the calendering of a web so as to obtain a continuous pattern of bonding area as opposed to discrete, discontinuous, pinpoint bonding. The high density discontinuous bonding pattern has a plurality of pinpoint bonds, generally resulting in a pin density of at least 400 pin points per square inch.

The ultralight materials of the present invention will generally maintain their shape during stretching and will not exhibit substantial "neck-in" upon being subjected to a strain. The ultralight fabric of the present invention minimizes such "neck-in" and has a dimensional stability comparable to fabrics that are much heavier (with basis weights higher than of 0.40 ounces per square yard).

The fabrics of the present invention may be made from various types of fibers including meltblown, spunbond, bi-component, and crimped fibers, such as disclosed in U.S. Patent No. 5,418,045 to Pike et al, which is hereby incorporated herein in its entirety by reference. The ultralight fabrics of the present invention can be used for liners and facing materials in disposable personal care absorbent articles such as diapers, training pants, incontinence garments, feminine hygiene products such as sanitary napkins, bandages, and the like, as well as various absorbent and barrier medical field products such as surgical gowns, drapes, sterile wraps, and the like. In addition, various laminates, such as elastic and film laminates, outer covers, side panels, diaper ears, absorbent liners, wipers, and various other products such as spunbond-meltblown-spunbond materials may employ the present invention.

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate one embodiment of the invention and, together with the description, serve to explain the principles of the invention.

## Brief Description of the Drawings

A full and enabling disclosure of the present invention,

including the best mode thereof, to one of ordinary skill in the art, is set forth more particularly in the remainder of the specification, including reference to the accompanying drawings, in which:

Figure 1 is a top elevational view of a pattern-unbonded nonwoven fabric of the present invention.

Figure 2 is a cross-sectional side view of the pattern-unbonded nonwoven fabric of Figure 1.

Figure 3 is a top elevational view of an alternative embodiment of a nonwoven fabric having a discontinuous bonding pattern.

Figure 4 is a schematic side view of a process and apparatus for making a pattern-unbonded nonwoven fabric of the present invention.

Figure 5 is a partial perspective view of a pattern roll that can be used in accordance with the process and apparatus of Figure 4.

Figure 6 is a perspective view of a disposable diaper with a fabric of the present invention composing the liner or facing that covers the absorbent core.

Figure 7 is a graph illustrating the Poisson Ratios of various pattern unbonded pattern fabrics at given fiber sizes (denier) and at given fabric basis weights (osy).

Figure 8 is a graph illustrating the Poisson Ratios of various pattern unbonded pattern fabrics and various control fabrics at given fibers sizes (denier) and at given fabric basis weights (osy).

Figure 9 is a graph illustrating the Poisson Ratios of various discontinuous bonding pattern fabrics at given fiber sizes (denier) and at given fabric basis weights (osy).

Figure 10 is a graph illustrating the Poisson Ratios of various discontinuous bonding pattern fabrics and various control fabrics at given fiber sizes (denier) and at given fabric basis weights (osy).

Figure 11 is a graph illustrating the Poisson Ratios of various pattern unbonded fabrics, various discontinuous bonding pattern fabrics and various control fabrics at given fiber sizes (denier) and at

given fabric basis weights (osy).

## Detailed Description of the Preferred Embodiments

Reference now will be made in detail to the presently preferred embodiments of the invention, one or more examples of which are illustrated in the accompanying drawings. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used on another embodiment to yield a still further embodiment. Thus, it is intended that the present invention cover such modifications and variations as come within the scope of the appended claims and their equivalents. The same numerals are assigned to the same components throughout the drawings and description.

### Definitions

"Spunbonded fibers" refers to small diameter fibers that are formed by extruding molten thermoplastic material as filaments from a plurality of fine, usually circular, capillaries of a spinneret with the diameter of the extruded filaments then being rapidly reduced. Examples of spunbonded fibers are set forth in in U.S. Patent No. 4,340,563 to Appel et al.,U.S. Patent No. 3,692,618 to Dorschner et al., U.S. Patent No. 3,802,817 to Matsuki et al., U.S. Patent No. 3,338,992 to Kinney, U.S. Patent No. 3,341,394 to Kinney, U.S. Patent No. 3,502,763 to Hartman, and U.S. Patent No. 3,542,615 to Dobo et al. Spunbond fibers are generally continuous and have average diameters (from a sample of at least 10) larger than 7 microns, more particularly, between about 10 and 40 microns. The fibers may also have shapes such as those described in U.S. Patent No. 5,277,976 to Hogle et al., U.S. Patent No. 5,466,410 to Hills, U.S. Patent No. 5,069,970 to Largman et al., and U.S. Patent No.

5,057,368 to Largman et al., which describe fibers with unconventional shapes.

"Meltblown fibers" refers to fibers formed by extruding a molten thermoplastic material through a plurality of fine, usually circular, die capillaries as molten threads or filaments into converging high velocity, usually hot, gas (e.g., air) streams which attenuate the filaments of molten thermoplastic material to reduce their diameter, which may be to microfiber diameter. Thereafter, the meltblown fibers are carried by the high velocity gas stream and are deposited on a collecting surface to form a web of randomly dispensed meltblown fibers. Such a process is disclosed, for example, in U.S. Patent No. 3,849,241 to Buntin et al. Meltblown fibers are microfibers, either continuous or discontinuous, and are generally smaller than 10 microns in average diameter.

"Conjugate fibers" refers to fibers which have been formed from at least two polymer sources extruded from separate extruders but spun together to form one fiber. Conjugate fibers are also sometimes referred to as multicomponent or bicomponent fibers. The polymers are usually different from each other though conjugate fibers may be monocomponent fibers. The polymers are arranged in substantially constantly positioned distinct zones across the cross-section of the conjugate fibers and extend continuously along the length of the conjugate fibers. The configuration of such a conjugate fiber may be, for example, a sheath/core arrangement wherein one polymer surrounds another or may be a side-by-side arrangement, a pie arrangement, or an "islands-in-the-sea" arrangement. Conjugate fibers are taught in U.S. Patent No. 5,108,820 to Kaneko et al., U.S. Patent No. 5,336,552 to Strack et al., and U.S. Patent No. 5,382,400 to Pike et al. For two-component fibers, the polymers may be present in ratios of 75/25, 50/50, 25/75 or any other desired ratios. The fibers may also have shapes such as those described in U.S. Patent No. 5,277,976 to Hogle et al., U.S. Patent 5,069,970 to Largman et al.,

and U.S. Patent 5,057,368 to Largman et al., hereby incorporated by reference in their entirety, which describe fibers with unconventional shapes. Polymers useful in forming conjugate fibers include those normally used in the spunbonding and meltblowing processes, including various polyolefins, nylons, polyesters, etc.

"Biconstituent fibers" refers to fibers which have been formed from at least two polymers extruded from the same extruder as a blend. Biconstituent fibers do not have the various polymer components arranged in relatively constantly positioned distinct zones across the cross-sectional area of the fiber and the various polymers are usually not continuous along the entire length of the fiber, instead usually forming fibrils or protofibrils which start and end at random. Biconstitutent fibers are sometimes also referred to as multiconstituent fibers. Fibers of this general type are discussed in, for example, U.S. Patent No. 5,108,827 to Gessner. Bicomponent and biconstituent fibers are also discussed in the textbook Polymer Blend and Composites by John A. Manson and Leslie H. Sperling, copyright 1976 by Plenum Press, a division of Plenum Publishing Corporation of New York, IBSN 0-306-308831-2, at pages 273-277.

"Bonded carded webs" refers to webs that are made from staple fibers which are sent through a combing or carding unit that separates or breaks apart and aligns the staple fibers in the machine direction to form a generally machine direction-oriented fibrous nonwoven web. Such fibers are usually purchased in bales which are placed in an opener/blender or picker that separates the fibers prior to the carding unit. Once the web is formed, it then is bonded by one or more of several known bonding methods. One such bonding method is powder bonding, wherein a powdered adhesive is distributed through the web and then activated, usually by heating the web and adhesive with hot air. Another suitable bonding method is pattern bonding, wherein heated calender rolls or ultrasonic bonding equipment are used to bond the fibers together, usually in a localized

bond pattern, though the web can be bonded across its entire surface if so desired. Another suitable and well-known bonding method, particularly when using bicomponent staple fibers, is through-air bonding.

"Airlaying" is a well-known process by which a fibrous nonwoven layer can be formed. In the airlaying process, bundles of small fibers having typical lengths ranging from about 3 to about 19 millimeters are separated and entrained in an air supply and then deposited onto a forming screen, usually with the assistance of a vacuum supply. The randomly deposited fibers are then bonded to one another using, for example, hot air or a spray adhesive.

As used herein, through-air bonding means a process of bonding a nonwoven bicomponent fiber web wherein air, which is sufficiently hot to melt one of the polymers from which the fibers of the web are made, is forced through the web. The air velocity is between 100 and 500 feet per minute and the dwell time may be a as long as 6 seconds. The melting and resolidification of the polymer provides the bonding. Through-air bonding has relatively restricted variability and because through-air bonding requires the melting of a least one component to accomplish bonding, it is restricted to webs with two components like conjugate fibers or those which include a separate adhesive such as a low melting fiber or adhesive additive. In the through-air bonder, air having a temperature above the melting temperature of one component and below the melting temperature of another component is directed into a perforated roller supporting the web. Alternatively, the through-air bonder may be a flat arrangement wherein the air is directed vertically downward onto the web. The operating conditions of the two configurations are similar, the primary difference being the geometry of the web during bonding. The hot air melts the lower melting polymer component and thereby forms bonds between the filaments to integrate the web.

As used herein, "pattern unbonded," or interchangeably "point

unbonded," means a fabric pattern having continuous bonded areas defining a plurality of discrete unbonded areas. Such a pattern is shown in Figures 1 and 2. The fibers or filaments within the discrete unbonded areas are dimensionally stabilized by the continuous bonded areas that encircle or surround each unbonded area. The unbonded areas are specifically designed to afford spaces between fibers or filaments within the unbonded areas.

As used herein, the term "discontinuous bonding pattern," or interchangeably "point bonded" or "point bonding," means a fabric pattern having discrete bond areas that are not continuous. Unlike a point unbonded pattern, a point bonded pattern has a plurality of separate bonding points surrounded by unbonded areas.

Various patterns of calender rolls have been developed for functional as well aesthetic reasons, but such patterns will not typically result in the high density discontinuous bonding patterns utilized in the present invention as defined below. One example of a pattern has points and is the Hansen Pennings or "H&P" pattern with about 30% bond area with about two hundred bonds per square inch as taught in U.S. Patent 3,855,046 to Hansen and Pennings, which is hereby incorporated herein in its entirety by reference. The H&P pattern has square point or pin bonding areas wherein each pin has a side dimension of 0.038 inches (0.965 mm), a spacing of 0.070 inches (1.778 mm) between pins, and a depth of bonding of 0.023 inches (0.584 mm). The resulting pattern has a bonded area of about 29.5%. Another typical point bonding pattern is the Expanded Hansen Pennings or "EHP" bond pattern which produces a 15% bond area with a square pin having a side dimension of 0.037 inches (0.94 mm) a pin spacing of 0.097 inches (2.464 mm) and a depth of 0.039 inches (0.991 mm). Another typical point bonding pattern designated "714" has square pin bonding areas wherein each pin has a side dimension of 0.023 inches, a spacing of 0.062 inches (1.575 mm) between pins, and a depth of bonding of 0.033 inches (0.838

mm). The resulting pattern has a bonded area of about 15%. Yet another common pattern is the C-Star pattern which has a bond area of about 16.9%. The C-Star pattern has a cross-directional bar or "corduroy" design interrupted by shooting stars. Other common patterns include a diamond pattern with repeating and slightly offset diamonds with about a 16% bond area and a wire weave pattern looking as the name suggests, e.g., like a window screen, with about a 19% bond area. Typically, the percent bonding area varies from about 10% to around 30% of the area of the fabric laminate web. As is well known in the art, the spot bonding holds the laminate layers together as well as imparts integrity to each individual layer by bonding filaments and/or fibers within each layer.

As used herein, the term "high density discontinuous bonding pattern" refers to a discontinuous bonding pattern that has a total bond density of at least about 400 pins per square inch.

As used herein, the term "machine direction" or "MD" means the direction in which the length of a fabric is produced on the machine that produces it. The term "cross machine direction" or "CD" means the width of a fabric, i.e., a direction generally perpendicular to the MD.

As used herein, the term "dimensionally stable" refers to a fabric that resists deformations such as the herein-described neck-in when subjected to converting operations. "Dimensionally stable" is a relative term and differentiates a particular fabric from other fabrics having comparable basis weights and/or fiber sizes. Dimensional stability is quantitatively defined herein by determination of the Poisson Ratio at 10% machine direction elongation as described.

Test Methods

The following methods were used to acquire the data presented in the tables set forth herein:

Basis Weight: The basis weights of various materials described herein were determined with Federal Test Method No.

191A\5041. Sample size for the sample materials was 15.24 x 15.24 cm, and three values were obtained for each material and then averaged. The values reported are for the average.

Denier: "Denier" is a measure of the the fiber size and specifically of the fineness of the fibers composing the web and is the mass measured in grams of 9000 meters of filament. It is expressed in "dpf", meaning "denier per filament".

Fabric Thickness: The "5-Inch Bulk Dry" parameter is measured in inches and is a measurement of the thickness of the fabric. The thickness of a textile fabric is defined as the distance between the upper and lower surfaces of the material, measured under a specified pressure. The average thickness of a textile material is usually determined by measuring the distance that a movable plane is displaced from a parallel surface by the textile fabric, under a specified pressure. In this procedure, the thickness of a 4" x 4" specimen of the fabric is measured using a dial comparator equipped with a 5" x 5" lucite platen. The pressure applied by the weight of the platen, weight attachment rod and added weights is 0.4 ± 0.01 lbs (182 ± 5 grams). (If a large enough specimen is not available, a circular contact point, 1" in diameter, may be substituted. In this instance, the specimen must be at least 1" in diameter). The thickness of the specimens is measured to the nearest thousandth of an inch. Five specimens are tested from each sample, and their average calculated.

Air Permeability: The air permeability is a measurement of the permeability of the fabric to air and is measured in cubic feet of air per square foot of fabric per minute passing through the fabric. During the test, the rate of air flow through a known area of fabric is adjusted to secure a prescribed pressure differential between the two surfaces of the fabric in the test area. From this rate of flow, the air permeability of the fabric is determined. A Textest FX-3300 Air Permeability Tester obtainable from Benninger Corporation of

Spartanburg, South Carolina may be utilized in performing the test. In performing the test, a specimen size of approximately 8 inches x 8 inches will typically be used, although other sizes greater than a minimum size 4 inches x 4 inches may be utilized. The specimen is clamped to the test head on the Permeability Tester and the vacuum pump is automatically started. The air permeability of the test specimen will be displayed in the selected units of measure (typically, cubic feet per square foot of fabric per minute).

Cup Crush: The softness of a nonwoven fabric may be measured according to the "cup crush" test. The cup crush test evaluates fabric stiffness by measuring peak load (also called the "cup crush load" or just "cup crush") and energy units with a constant-rate-of-extension tensile testing machine. Stiffer materials will exhibit higher peak load values. The peak load measured is that required for a 4.5 cm diameter hemispherically-shaped foot to crush a piece of fabric approximately 23 cm x 23 cm and shaped into an approximately 6.5 cm diameter by 6.5 cm tall inverted cup while the cup-shaped fabric is surrounded by an approximately 6.5 cm diameter cylinder to maintain a uniform deformation of the cup-shaped fabric. The foot and the cup are aligned to avoid contact between the cup walls and the foot which could affect the readings. The peak load is measured while the foot is descending at a rate of about 400 mm per minute and is measured in grams (or pounds).

The cup crush test also yields a value (the "cup crush energy") for the total energy required to crush a sample. The cup crush energy is the energy from the start of the test to the peak load point, i.e., the area under the curve formed by the load in grams on one axis and the distance the foot travels in millimeters on the other axis. Cup crush energy is therefore reported in grams/millimeters (or pounds/inch). Lower cup crush values indicate a softer nonwoven web.

A suitable device for measuring cup crush is a constant-rate-

of-extension tester machine available from Sintech Corporation of Cary, North Carolina. The machine used is one in which the rate of increase of the test specimen length is uniform with time.

Drape: The "drape" of a material expresses the stiffness of the fabric in a bending mode. A cantilever bending test is used to determine the bending length of a fabric using the principle of cantilever bending of the fabric under its own weight. The bending length is a measure of the interaction between fabric weight and fabric stiffness as shown by the way in which a fabric bends under its own weight. In performing the test, a total of 10 - 1" by 8" specimens are slid at 4.75" per minute in a direction parallel to their long dimensions so that the leading edges project from the edge of a horizontal surface. The length of the overhang is measured when the tips of the specimens are depressed under their own weight to a point where the line joining the tips to the edge of the platform makes a 41.5° angle with the horizontal platform. The longer the overhang, the slower the specimen was to bend; thus, higher numbers indicate a stiffer fabric. The procedure used conforms to ASTM Standard Test D 1388 with the exception that a specimen size of 1" by 8" is used instead of 1" by 6'. The test employs equipment such as a Cantilever Bending Tester, Model 79-10 available from Testing Machines Inc. of Amityville, New York. When fabrics other than polypropylene-based materials are used, ASTM conditions or TAPPI conditions should be utilized. In addition, 5 specimens should be cut in the machine direction, and 5 specimens should be cut in the cross-machine direction. The overhang lengths of the various specimens are recorded from the linear scale of the tester. Results are reported as bending lengths and specimens in the machine direction should be reported separately from specimens in the cross-machine direction. The drape stiffness is reported in inches and is the bending length divided by 2.

Poisson Ratio 10% MD Elongation: The "Poisson Ratio 10%

MD Elongation" is a measurement of the dimensional stability of the fabric. The lower the Poisson Ratio, the better the dimensional stability of the fabric. In particular, the Poisson Ratio is a measurement of the relative change in width with a change in length. The better the dimensional stability of the fabric, the lesser the tendency of the fabric to "neck in" during the converting process. The Poisson ratio is a dimensionless number calculated by the following formula:

$$\text{Ratio} = \frac{\dfrac{(W_0 - W_i)}{W_0}}{\dfrac{(L_i - L_0)}{L_0}}$$

where: $W_0$ is the initial sample width (typically 75 mm or 3 inches).

$W_i$ is the sample width at an extended length $L_i$.

$L_0$ is the initial sample length (typically 300 mm or 12 inches), and the value of $L_0$ is a minimum of four (4) times larger than $W_0$'s value.

$L_i$ is the sample length at a given extension.

A Sintech (or similar equipment such as an Instron machine) is required to conduct the test, as the following illustrates.

1. For a jaw span of 300 mm or 12 inches, the sample length ($L_0$) is cut to a minimum of 38 cm (380 mm or 15 inches) with a sample width of 75 mm or 3 inches ($W_0$). If a different jaw span is used, the sample width should not be more than 0.25 times the jaw span. The jaw face should be at least as wide as the sample width.
2. A line is drawn across the center of the sample. All measurements of the sample width are on this line with an accuracy of 0.50 mm or 0.02 inches.
3. A sample specimen is placed between the jaws on the Sintech with minimal slack or stretch in the sample.

4. The initial sample width ($W_0$) is measured and recorded with an accuracy of 0.50 mm or 0.02 inches. The initial sample length (or starting jaw span) is also recorded.
5. The sample length is increased by manually extending the jaw span. Typically, this is done in steps of 1% extension (i.e., 300 mm to 303 mm; 303 mm to 306 mm; 306 mm to 309 mm; etc.) up to a maximum of 10% extension.
6. The sample width is measured at the first extension with an accuracy of 0.50 mm or 0.02 inches, along with the extended sample length (current jaw span). This is repeated for all subsequent extensions.

Grab Tensile Test: The Grab Tensile Test is a measure of breaking strength or elongation or strain of a fabric when subjected to unidirectional stress. This test is known in the art and conforms to the specifications of method 5100 of the Federal Test Methods Standard 191A. The "Grab Tensile Peak Load" is measured in pounds and is the breaking load before rupture of a fabric being subjected to a constant rate of extension in a single direction, typically either the cross direction (CD) of the fabric or the machine direction (MD) of the fabric. The "Grab Tensile Peak Strain Percentage" is a measure of the percent elongation of the fabric before rupture, i.e., "the stretchability" of a fabric, at a constant rate of extension in a single direction, typically either the cross direction (CD) of the fabric or the machine direction (MD) of the fabric. The term "elongation" or "strain" means the increase in length of a specimen during a tensile test and is given in percent. Higher numbers indicate a stronger, more stretchable fabric. The term "total energy" means the total energy expressed in weight-length units as the area under a curve of the load versus the elongation of the fabric. The "Grab Tensile Peak Energy" is the total energy just before rupture.

The following is an example of the grab test. This grab test

procedure conforms closely to ASTM Standards D-5034-92 and D-5035-92 and INDA 1ST 110.1-92, using a Constant-Rate-of-Extension (CRE) Tensile Testing Machine in which the rate of increase of the specimen length is uniform with time. The grab test is conducted in a standard laboratory atmosphere of 73.4 ± 3.6°F (23 ± 2° C) and 50 ± 5% Relative Humidity (RH). In case of disagreement, the tolerances shall be ± 1.8°F (1° C) and ± 2% RH. In specific cases, such as control testing, where the conditioning requirements cannot be met and the data still may be of direct assistance to the operation, other conditioning procedures may be used, provided these replacement conditions are reported. The material is measured only after sufficient time has been allowed for the specimens to reach essential equilibrium with the ambient atmosphere. Values for grab tensile strength and grab elongation are obtained using a specified width of fabric, usually 4 inches (102 mm), clamp width and a constant rate of extension. The sample is wider than the clamp to give results representative of effective strength of fibers in the clamp width combined with additional strength contributed by adjacent fibers in the fabric. A four inch (4 in) (100 mm) wide specimen is centrally clamped in the jaws of the tensile testing machine, for example, an Instron Model TM, available from the Instron Corporation, 2500 Washington Street, Canton, Massachusetts 02021, or a Thwing-Albert Model INTELLECT II, available from the Thwing-Albert Instrument Co., 10960 Dutton Road, Philadelphia, Pennsylvania 19154, which have 3 inch (76 mm) long parallel clamps. This closely simulates fabric stress conditions in actual use. A force is applied until the specimen breaks. Values for the breaking force and the elongation of the test specimen are obtained from machine scales, dials, autographic recording charts, or a computer interfaced with the test machine. The grab test procedure determines the effective strength of the fabric; that is, the strength of the fibers in a specific width together with the fabric assistance from adjacent fibers. The

breaking force determined by the grab procedure is not a reflection of the strength of the fibers actually gripped between jaw faces and cannot be used for direct comparison with fiber strength determinations. Moreover, there is no simple relationship between grab tests and strip tests since the amount of fabric assistance depends on the type of fabric and construction variables.

The "Strip Tensile Peak Load" is measured in pounds and is the breaking load before rupture of a strip of fabric at a constant rate of extension in a single direction, typically either the cross direction (CD) of the fabric or the machine direction (MD) of the fabric. The "Strip Tensile Peak Strain Percentage" is a measure of the percent elongation of a strip of the fabric before rupture, i.e., "the stretchability" of a strip of fabric, at a constant rate of extension in a single direction, typically either the cross direction (CD) of the fabric or the machine direction (MD) of the fabric. The following is an example of the strip test. A four inch (4 in) (100 mm) wide specimen is mounted centrally in the jaws of the tensile testing machine, and a force is applied until the specimen breaks. Values for the breaking force and the elongation of the test specimen are obtained from machine scales, dials, autographic recording charts, or a computer interfaced with the test machine. The strip test procedure determines the effective strength of the fabric; that is, the strength of the fibers in a specific width together with the fabric assistance from adjacent fibers.

## Detailed Description

The typical disposable personal care absorbent article includes a liquid permeable body side liner. As shown in Figure 6 for example, a diaper 60 includes a liquid permeable body side liner 64. The various nonwoven fabrics of the present invention can be used for the body side liner, or facing, 64. For example, the web comprising the body side liner may be composed of a meltblown or spunbond nonwoven web of synthetic fibers like thermoplastic fibers such as

polyolefin fibers for example, melt-spun filaments, staple fibers, melt-spun multicomponent filaments.

The fibers may be formed from a variety of thermoplastic polymers where the term "thermoplastic polymer" refers to a long chain polymer that softens when exposed to heat and returns to its original state when cooled to ambient temperature. Exemplary thermoplastics include, without limitation, poly(vinyl) chlorides, polyesters, polyamides, polyfluorocarbons, polyolefins, polyurethanes, polystyrenes, poly(vinyl) alcohols, caprolactams, and copolymers of the foregoing, and elastomeric polymers such as elastic polyolefins, copolyether esters, polyamide polyether block copolymers, ethylene vinyl acetates (EVA), block copolymers having the general formula A-B-A' or A-B like copoly(styrene/ethylene-butylene), styrene-poly(ethylene-propylene)-styrene, styrene-poly(ethylene-butylene)-styrene, (polystyrene/poly(ethylene-butylene)/polystyrene, poly(styrene/ethylene-butylene/styrene), A-B-A-B tetrablock copolymers and the like.

The fibers or filaments used in making the nonwoven material may have any suitable morphology and may include hollow or solid, straight or crimped, single component, conjugate or biconstituent fibers or filaments, and blends or mixes of such fibers and/or filaments, as are well known in the art. All such nonwoven webs may be pre-bonded or otherwise consolidated, using known nonwoven web bonding techniques such as the hot air knife, compaction rolls, through-air bonding, ultrasonic bonding and stitchbonding, and subsequently bonded using the methods and apparatus of the present invention, or alternatively, such nonwoven webs may only be bonded using the methods and apparatus of this invention.

Many polyolefins are available for fiber production, for example polyethylenes such as Dow Chemical's PE XU 61800.41 linear low density polyethylene ("LLDPE") and 25355 and 12350 high density polyethylene ("HDPE") are such suitable polymers. Fiber forming

polypropylenes include Exxon Chemical Company's Escorene® PD 3445 polypropylene and Montell Chemical Co.'s PF-304 and PF-015. Many other conventional polyolefins are commercially available and include polybutylenes and others.

Examples of polyamides and their methods of synthesis may be found in "Polymer Resins" by Don E. Floyd (Library of Congress Catalog No. 66-20811, Reinhold Publishing, New York, 1966). Particularly commercially useful polyamides are nylon-6, nylon 6,6, nylon-11 and nylon-12. These polyamides are available from a number of sources such as Emser Industries of Sumter, South Carolina (Grilon® & Grilamid® nylons), Atochem Inc. Polymers Division of Glen Rock, New Jersey (Rilsan® nylons), Nyltech of Manchester, New Hampshire (grade 2169, Nylon 6), and Custom Resins of Henderson, Kentucky (Nylene 401-D), among others.

Useful elastomeric resins include block copolymers having the general formula A-B-A' or A-B, where A and A' are each a thermoplastic polymer endblock which contains a styrenic moiety such as a poly(vinyl arene) and where B is an elastomeric polymer midblock such as a conjugated diene or a lower alkene polymer. Block copolymers for the A and A' blocks, and the present block copolymers are intended to embrace linear, branched and radial block copolymers. In this regard, the radial block copolymers may be designated $(A\text{-}B)_m\text{-}X$, wherein X is a polyfunctional atom or molecule and in which each $(A\text{-}B)_m$- radiates from X in a way that A is an endblock. In the radial block copolymer, X may be an organic or inorganic polyfunctional atom or molecule and m is an integer having the same value as the functional group originally present in X. It is usually at least 3, and is frequently 4 or 5, but not limited thereto. Thus, in the present invention, the expression "block copolymer," and particularly "A-B-A" and "A-B" block copolymer, is intended to embrace all block copolymers having such rubbery blocks and thermoplastic blocks as discussed above, which can be extruded

(e.g., by meltblowing), and without limitation as to the number of blocks. The elastomeric nonwoven web may be formed from, for example, elastomeric (polystyrene/poly(ethylene-butylene)/ polystyrene) block copolymers. Commercial examples of such elastomeric copolymers are, for example, those known as KRATON® materials which are available from Shell Chemical Company of Houston, Texas. KRATON® block copolymers are available in several different formulations, a number of which are identified in U.S. Patent Nos. 4,663,220, 4,323,534, 4,834,738, 5,093,422 and 5,304,599.

Polymers composed of an elastomeric A-B-A-B tetrablock copolymer may also be used in the practice of this invention. Such polymers are discussed in U.S. Patent No. 5,332,613 to Taylor et al. In such polymers, A is a thermoplastic polymer block and B is an isoprene monomer unit hydrogenated to substantially a poly(ethylene-propylene) monomer unit. An example of such a tetrablock copolymer is a styrene-poly(ethylene-propylene)-styrene-poly(ethylene-propylene) or SEPSEP elastomeric block copolymer available from the Shell Chemical Company of Houston, Texas under the trade designation KRATON® G-1657.

Other exemplary elastomeric materials which may be used include polyurethane elastomeric materials such as, for example, those available under the trademark ESTANE® from B.F. Goodrich & Co. or MORTHANE® from Morton Thiokol Corp., polyester elastomeric materials such as, for example, those available under the trade designation HYTREL® from E.I. DuPont De Nemours & Company, and those known as ARNITEL®, formerly available from Akzo Plastics of Amhem, Holland and now available from DSM of Sittard, Holland.

Another suitable material is a polyester block amide copolymer having the formula:

$$HO{-}[{-}\overset{\overset{\displaystyle O}{|}}{C}{-}{-}PA{-}\overset{\overset{\displaystyle O}{|}}{C}{-}PE{-}{-}O{-}]_n{-}H$$

where n is a positive integer, PA represents a polyamide polymer segment and PE represents a polyether polymer segment. In particular, the polyether block amide copolymer has a melting point of from about 150°C to about 170°C, as measured in accordance with ASTM D-789; a melt index of from about 6 grams per 10 minutes to about 25 grams per 10 minutes, as measured in accordance with ASTM D-1238, condition Q (235 C/1Kg load); a modulus of elasticity in flexure of from about 20 Mpa to about 200 Mpa, as measured in accordance with ASTM D-790; a tensile strength at break of from about 29 Mpa to about 33 Mpa as measured in accordance with ASTM D-638 and an ultimate elongation at break of from about 500 percent to about 700 percent as measured by ASTM D-638. A particular embodiment of the polyether block amide copolymer has a melting point of about 152°C as measured in accordance with ASTM D-789; a melt index of about 7 grams per 10 minutes, as measured in accordance with ASTM D-1238, condition Q (235 C/1Kg load); a modulus of elasticity in flexure of about 29.50 Mpa, as measured in accordance with ASTM D-790; a tensile strength at break of about 29 Mpa, a measured in accordance with ASTM D-639; and an elongation at break of about 650 percent as measured in accordance with ASTM D-638. Such materials are available in various grades under the trade designation PEBAX® from ELF Atochem Inc. of Glen Rock, New Jersey. Examples of the use of such polymers may be found in U.S. Patent Nos. 4,724,184, 4,820,572 and 4,923,742 to Killian.

Elastomeric polymers also include copolymers of ethylene and at least one vinyl monomer such as, for example, vinyl acetates, unsaturated aliphatic monocarboxylic acids, and esters of such monocarboxylic acids. The elastomeric copolymers and formation of elastomeric nonwoven webs from those elastomeric copolymers are disclosed in, for example, U.S. Patent No. 4,803,117.

The thermoplastic copolyester elastomers include copolyetheresters having the general formula:

$$H-([O-G-O-\overset{\mathrm{O}}{\overset{|}{C}}-C_6H_4-\overset{\mathrm{O}}{\overset{|}{C}}]_b-[O-(CH_2)_a-O-\overset{\mathrm{O}}{\overset{|}{C}}-C_6H_4-\overset{\mathrm{O}}{\overset{|}{C}}]_m)_n-O-(CH_2)_a-OH$$

where "G" is selected from the group consisting of poly(oxyethylene)-alpha,omega-diol, poly(oxypropylene)-alpha,omega-diol, poly(oxytetramethylene)-alpha,omega-diol and "a" and "b" are positive integers including 2, 4 and 6, "m" and "n" are positive integers including 1-20. Such materials generally have an elongation at break of from about 600 percent to 750 percent when measured in accordance with ASTM D-638 and a melt point of from about 350°F to about 400°F (176 to 205°C) when measured in accordance with ASTM D-2117.

Commercial examples of such copolyester materials are, for example, those known as ARNITEL®, formerly available from Akzo Plastics of Amhem, Holland and now available from DSM of Sittard, Holland, or those known as HYTREL® which are available from E.I. DuPont de Nemours of Wilmington, Delaware. Formation of an elastomeric nonwoven web from polyester elastomeric materials is disclosed in, for example, U.S. Patent No. 4,741,949 to Morman et al. and U.S. Patent No. 4,707,398 to Boggs.

Elastomeric olefin polymers are available from Exxon Chemical Company of Baytown, Texas under the trade name ACHIEVE® for polypropylene based polymers and EXACT® and EXCEED® for polyethylene based polymers. Dow Chemical Company of Midland, Michigan has polymers commercially available under the name ENGAGE®. These materials are believed to be produced using non-stereo selective metallocene catalysts. Exxon generally refers to their metallocene catalyst technology as "single site" catalysts while Dow refers to theirs as "constrained geometry" catalysts under the name INSIGHT® to distinguish them from traditional Ziegler-Natta catalysts which have multiple reaction sites.

In accordance with an embodiment of the present invention, an

ultralight fabric may be formed from a nonwoven web having a fibrous structure of individual fibers or filaments. The nonwoven webs of the present invention, both the pattern unbonded and pattern bonded fabrics, will be ultra lightweight fabrics that exhibit a greater relative dimensional stability over fabrics of similar weights that have not been made according to the present invention. In particular, the fabrics of the present invention will have a basis weight of about 0.40 ounces per square yard (osy) or less. More specifically, the fabrics may have basis weights of about 0.30 osy or less. In addition, the fabrics may have basis weights of about 0.20 osy or less. The minimum basis weight for the fabrics of the present invention will depend on the particular use which is to be made of the fabric, with lighter weight fabrics being an object of the invention. For example, webs having basis weights as low as 0.10 osy may be utilized in the present invention, although any lightweight fabric having the inventive characteristics falls within the scope of the invention.

The bonding areas for the present invention, whether pattern unbonded or pattern bonded fabrics, will be in the range of 50% total bond area or less. More specifically, the bond areas of the present inventive webs will be in the range of 40% total bond area or less. Even more specifically, the bond areas will be in the range of 30% total bond area or less and may be in the range of about 15% total bond area or less. Typically, a minimum bond area of at least about 10% will be acceptable for creating the lightweight, clothlike, webs of the present invention, although other total bond areas will fall within the scope of the invention, depending on the particular characteristics desired in the final product. Stated generally, the lower limit on the percent bond area suitable for forming the nonwoven ultralight material of the present invention is the point at which fiber pull-out excessively reduces the surface integrity and durability of the material. The required percent bond areas will be affected by a number of factors, including the type(s) of polymeric materials used in

forming the fibers or filaments of the nonwoven web, whether the nonwoven web is a single- or multi-layer fibrous structure, and the like. Bond areas ranging from about 15% to about 50%, and more particularly from about 15% to about 40%, have been found suitable.

Various methods may be utilized in bonding the webs of the present invention. Such methods include through-air bonding and thermal point bonding as described in U.S. Patent No. 3,855,046 to Hansen et al., which is incorporated herein in its entirety by reference. In addition, other means of bonding, such as ovenbonding, ultrasonic bonding, hydroentangling, or combinations of such techniques, may be utilized in certain instances.

As shown in Figures 1 and 2, one particular fabric of the present invention can be formed as a pattern unbonded fabric 4 where continuous bonded areas 6 define a plurality of discrete, dimensionally-stabilized unbonded areas 8 in the nonwoven fabric 4.

A suitable process for forming the pattern-unbonded nonwoven material of this invention, as further exemplified herein, includes providing a nonwoven fabric or web, providing opposedly positioned first and second calender rolls and defining a nip therebetween, with at least one of said rolls being heated and having a bonding pattern on its outermost surface comprising a continuous pattern of land areas defining a plurality of discrete openings, apertures or holes, and passing the nonwoven fabric or web within the nip formed by said rolls. Each of the openings in said roll or rolls defined by the continuous land areas forms a discrete unbonded area in at least one surface of the nonwoven fabric or web in which the fibers or filaments of the web are substantially or completely unbonded. Stated alternatively, the continuous pattern of land areas in said roll or rolls forms a continuous pattern of bonded areas that define a plurality of discrete unbonded areas on at least one surface of said nonwoven fabric or web. Alternative embodiments of the aforesaid process includes pre-bonding or consolidating the nonwoven fabric or web

before passing the fabric or web within the nip formed by the calender rolls, or providing multiple nonwoven webs to form a pattern-unbonded laminate. Pattern-unbonded fabrics are disclosed in U.S. Patent Application No. 08/754,419, commonly assigned and are shown in Figures 1 and 2 where continuous bonded areas 6 define a plurality of discrete, dimensionally-stabilized unbonded areas 8 in the nonwoven fabric 4.

Referring now to Figures 4 and 5, one exemplary process and apparatus for forming the pattern-unbonded nonwoven material of this invention will be specifically described. In Figure 4, apparatus for forming the pattern-unbonded nonwoven material of this invention is represented generally as element 34. The apparatus 34 can include a first web unwind 36 and a pattern-unbonding assembly 40. As shown in Figure 4 for example, a web 38 of ultralight material having a basis weight less than 0.40 ounces per square yard is taken off the unwind 36 and passed into pattern-unbonding assembly 40 that includes a first or pattern roll 42 and a second or anvil roll 44, both of which are driven by conventional drive means, such as, for example, electric motors (not shown). Additional fabric unwinds may be utilized (not shown) when it is desired to construct multilayer laminates according to the present invention. In addition, it will be appreciated that the nonwoven material may be supplied directly from the machine which forms the fabric itself instead of being unwound from a roll.

Pattern roll 42 is a right circular cylinder that may be formed of any suitable, durable material, such as, for example, steel, to reduce wear on the rolls during use. Pattern roll 42 has on its outermost surface a pattern of land areas 46 that define a plurality of discrete openings or apertures 48. The land areas 46 are designed to form a nip 50 with the smooth or flat outer surface of opposedly positioned anvil roll 44, which also is a right circular cylinder that can be formed of any suitable, durable material.

As shown in Figure 4, the nonwoven ultralight fabric or web 38 is passed within the nip 50 formed by the rolls 42, 44. Each of the openings 48 in the roll 42 or rolls defined by the continuous land areas 46, forms a discrete unbonded area 8 (Figures 1 and 2) in at least one surface of the nonwoven fabric or web 4 (Figures 1 and 2) in which the fibers or filaments of the web are substantially or completely unbonded. Stated alternatively, the continuous pattern of land areas 46 in the roll 42 or rolls forms a continuous pattern of bonded areas 6 (Figures 1 and 2) that define a plurality of discrete unbonded areas 8 (Figures 1 and 2) on at least one surface of the nonwoven fabric or web 4.

As shown in Figure 5, in forming the pattern-unbonded nonwoven material 4 of the present invention, openings 48 can have an average diameter ranging from about 0.050 inch (about 0.127 cm) to about 0.250 inch (about 0.635 cm), and more specifically, from about 0.100 inch (0.330 cm) to about 0.160 inch (0.406 cm), and a depth measured from the outermost surface of pattern roll 42 of at least about 0.020 inch (about 0.051 cm), and more particularly at least about 0.060 inch (0.152 cm). Moreover, while openings 48 in pattern roll 42 as shown in Figure 5 are circular, other shapes, such as ovals, squares, diamonds, and the like, can be advantageously employed.

The number or density of openings 48 in pattern roll 42 also can be selected to provide the requisite dimensional stability for the ultralight fabric. Pattern rolls having an opening density in the range of from about 1.0 opening per square centimeter ($cm^2$) to about 25.0 openings/$cm^2$, and more particularly from about 5.0 to about 7.0 openings/$cm^2$, may be utilized in forming the pattern-unbonded fabric 4 of the present invention. Moreover, the spacing between individual openings 48 can be selected in a range from about 0.13 inch (about 3.30 mm) to about 0.22 inch (about 5.59 mm), centerline-to-centerline, in the machine and cross-machine directions.

The particular arrangement or configuration of openings 48 in pattern roll 42 are chosen so that in combination with the opening size, shape and density, the desired levels of dimensional stability are achieved. For example, as shown in Figure 5, the individual openings 48 are arranged in staggered rows (see also Figure 1). Other different configurations are considered within the scope of the present invention.

The portion of the outermost surface of the pattern roll 42 occupied by continuous land areas 46 likewise can be modified to satisfy the contemplated end-use application of the pattern-unbonded material. The degree of bonding imparted to the pattern-unbonded nonwoven ultralight material by the continuous land areas 46 can be expressed as a percent bond area, which refers to the portion of the total plan area of at least one surface of the pattern-unbonded nonwoven material 4 (see Figure 1) that is occupied by bonded areas 6.

The temperature of the outer surface of pattern roll 42 can be varied by heating or cooling relative to anvil roll 44. Heating and/or cooling can affect the features of the web(s) being processed and the degree of bonding of single or multiple webs being passed through the nip formed between the counter-rotating pattern roll 42 and anvil roll 44. In the embodiment shown in Figure 4 for example, both pattern roll 42 and anvil roll 44 are heated, desirably to the same bonding temperature. The specific range of temperatures to be employed in forming the pattern-unbonded nonwoven material hereof is dependent upon a number of factors, including the types of polymeric materials employed in forming the pattern-unbonded material, the inlet or line speed(s) of the nonwoven web(s) passing through the nip formed between pattern roll 42 and anvil roll 44, and the nip pressure between pattern roll 42 and anvil roll 44.

Anvil roll 42 as shown in Figure 4 has an outer surface that is much smoother than pattern roll 42, and preferably is smooth or flat.

It is possible, however, for anvil roll 44 to have a slight pattern on its outer surface and still be considered smooth or flat for purposes of the present invention. Such surfaces are collectively referred to herein as "flat." Anvil roll 44 provides the base for pattern roll 42 and the web or webs of material to contact. Typically, pattern roll 42 and anvil roll 44 will be made from steel.

Alternatively, anvil roll 44 may be replaced with a pattern roll (not shown) having a pattern of continuous land areas defining a plurality of discrete, apertures or openings therein, as in the above-described pattern roll 42. In such case, the pattern-unbonding assembly would include a pair of counter-rotating pattern rolls which would impart a pattern of continuous bonded areas defining a plurality of discrete unbonded areas on both the upper and lower surfaces of the pattern-unbonded nonwoven material. Rotation of the opposedly positioned pattern rolls can be synchronized, such that the resulting unbonded areas on the surfaces of the pattern-unbonded material are vertically aligned or juxtaposed.

Referring again to Figure 4, a pattern roll 42 and an anvil roll 44 are rotated in opposite directions of one another so as to draw the nonwoven ultralight web 38 through the nip area defined therebetween. Pattern roll 42 has a first rotational speed measured at its outer surface and anvil roll 44 has a second rotational speed measured at its outer surface. In the embodiment shown, the first and second rotational speeds are substantially identical. However, the rotational speeds of the pattern and anvil rolls can be modified to create a speed differential between the counter-rotating rolls.

As shown in the alternative embodiment shown in Figure 3, an ultralight fabric 5 can be provided in the form of a point-bonded ultralight fabric where continuous unbonded areas 7 (undarkened) define a plurality of discrete, dimensionally-stabilized point bonded areas 9 (darkened) in the nonwoven fabric 5. The fabric 5 is formed from a nonwoven web having a fibrous structure of individual fibers or

filaments. The nonwoven web is an ultralight fabric 5 and thus has a basis weight of less than 0.40 osy. The pattern of point-bonded areas 9 can be formed in various shapes, with rectangular shapes being shown in Figure 3, in which the density of point bonded areas 9 relative to unbonded areas 7 is not to scale in order to be able to illustrate same. To show the point bonded areas 9 to scale for the high densities of the present invention, would crowd the point bonded areas 9 together so as to make it difficult to distinguish the continuous unbonded areas 7 therebetween.

In forming the discontinuous bonding patterns of the present invention, a fabric or web of fibers to be bonded is passed between a heated calender roll and an anvil roll. The calender roll is patterned in some way so that areas of the fabric are unbonded, and the anvil roll is usually flat.

As in the pattern unbonded embodiment of fabric 4, fabric 5 has a dimensional stability characterized by a factor calculated by multiplying the nonwoven web's Poisson Ratio at 10% elongation in the machine direction by the nonwoven web's basis weight, wherein said factor is equal to or less than 1.20 osy•PR.

In a further embodiment of the present invention, the ultralight fabric as previously described may be used to form a liquid permeable body side liner 64 for a personal care product such as a diaper 60 (shown in Figure 6). In the diaper embodiment shown in Figure 6, disposed between liner 64 and outer cover 62 is an absorbent core 66 formed, for example, of a blend of hydrophillic cellulosic wood pulp fluff fibers and highly absorbent gelling particles (e.g., superabsorbent). Elastic members may be disposed adjacent each longitudinal edge 68 of diaper 60 to draw and hold the lateral, side margins 68 of diaper 60 against the legs of the wearer. Additionally, elastic members also may be disposed adjacent either or both of the end edges 70 of diaper 60 to provide an elasticized waistband. Diaper 60 may further include optional containment flaps

72 made from or attached to body side liner 64. Suitable constructions and arrangements for such containment flaps are described, for example, in U.S. Patent No. 4,704,116 to Enloe, the disclosure of which is incorporated herein in its entirety by reference. The means for securing diaper 60 about the wearer may be a hook and loop fastening system including hook elements 74 attached to the inner and/or outer surface of outer cover 62 in the back waistband region of diaper 60 and one or more loop elements or patches 76 made from pattern-unbonded loop material attached to the outer surface of outer cover 62 in the front waistband region of diaper 60.

Referring to the tables, "PU" represents the pattern-unbonded fabrics and "DB" represents the discontinuous bonded fabrics. The control samples (all being discontinuous bonded fabrics) in the series of "A" tables, have the following bond patterns:

| | | |
|---|---|---|
| Control #1 | 15-20% Bond Area | 302 pins/inch$^2$ |
| Control #2 | 9-20% Bond Area | 102 pins/inch$^2$ |
| Control #3 | 15-20% Bond Area | 302 pins/inch$^2$ |
| Fitessa Control | 18% Bond Area | 204 pins/inch$^2$ |
| Kami Control | 18% Bond Area | 204 pins/inch$^2$ |
| Polybond Control | 18% Bond Area | 204 pins/inch$^2$ |

The Control #1 fabric is a spun bonded wire weave pattern. The Control #2 fabric has a delta dot pattern. The Control #3 fabric has a wire weave pattern. The remaining three controls are commercially available fabrics, obtainable from the named companies (Fitessa, KAMI and Polybond).

Referring to the tables, the samples of the present invention denoted "Inventive Discontinuous Bonded Fabric" in the series of "B" tables, have a Dense Diamond pattern with a bond area in the 15% to 18% range, but with the bond points spaced very close together to yield a pin density of 460 pins/inch$^2$. The pin side dimension in this pattern is 0.018 inch. The pin-to-pin distance (center to center) in the cross-machine direction is 0.086 inch and in the machine direction is

0.050, when measured along the same row, with alternate rows being staggered. The depth of bonding is 0.024 inch in this pattern This fabric exemplifies the pattern bonded fabric of the present invention. The samples denoted Inventive Pattern-Unbonded Fabrics exemplify the pattern unbonded fabrics of the present invention.

The polymers used for the Control fabrics listed above and the Inventive Fabrics (Discontinuous Bonded and Pattern-Unbonded) described below are as follows:

| | |
|---|---|
| Control #1 | PP (polypropylene) 35 MFR Union Carbide E5D47 with 2%$TiO_2$ |
| Control #2 | PP 35 MFR Union Carbide E5D47 with 2%$TiO_2$ |
| Control #3 | PP 35 MFR Exxon 3445 with 2%$TiO_2$ |
| Inventive Discontinuous Bonded Fabric | PP 35 MFR Union Carbide E5D47 with 2%$TiO_2$ |
| Inventive Pattern-Unbonded Fabric #1 | PP 35 MFR Exxon 3445 with 2%$TiO_2$ (Samples 10, 11, 12, 13, 15, 16, 18, 19, 20, 21) |
| Inventive Pattern-Unbonded Fabric #2 | PP 35 MFR Exxon 3445 with 2%$TiO_2$ (Samples 9, 14, 17) |

TABLE I-A
(Control Fabrics)

| Control Fabric | Basis Weight ($oz/yd^2$) | Denier (dpf) | 5" Bulk Dry (inches) | Air Permeability ($ft^3/ft^2/min$) | Cup Crush Load (grams) |
|---|---|---|---|---|---|
| Control #1 | 0.549 | 2.20 | 0.014 | 1053 | 29 |
| Control #2 | 0.30 | 1.86 | 0.009 | 1404 | 10 |
| Control #3 | 0.40 | 1.82 | 0.010 | 1065 | 26 |
| Fitessa Control | 0.48 | 2.53 | 0.011 | 987 | 27 |
| KAMI Control | 0.29 | 2.9 | 0.008 | 1556 | 17 |
| Polybond Control | 0.51 | 2.98 | 0.013 | 1101 | 14 |

TABLE I-B
(Inventive Discontinuous Bonded Fabric)

| Sample of Pattern Bonded | Basis Weight ($oz/yd^2$) | Denier (dpf) | 5" Bulk Dry (inches) | Air Permeability ($ft^3/ft^2/min$) | Cup Crush Load (grams) |
|---|---|---|---|---|---|
| 1 | 0.44 | 1.10 | 0.006 | 584 | 58 |
| 2 | 0.33 | 1.10 | 0.006 | 862 | 30 |
| 3 | 0.23 | 1.10 | 0.003 | 1170 | 19 |
| 4 | 0.16 | 1.10 | 0.004 | 1580 | 12 |
| 5 | 0.18 | 1.40 | 0.004 | N.D. | 13 |
| 6 | 0.21 | 1.40 | 0.004 | 1468 | 16 |
| 7 | 0.31 | 1.40 | 0.006 | 1001 | 22 |
| 8 | 0.42 | 1.40 | 0.007 | 772 | 39 |

TABLE I-C
(Inventive Pattern-Unbonded Fabrics #1 and 2)

| Sample of Pattern Unbonded | Basis Weight (oz/yd$^2$) | Denier (dpf) | 5" Bulk Dry (inches) | Air Permeability (ft$^3$/ft$^2$/min) | Cup Crush Load (grams) |
|---|---|---|---|---|---|
| 9 | 0.119 | 1.23 | 0.004 | N.D. | 3 |
| 10 | 0.189 | 2.10 | 0.006 | N.D. | 8 |
| 11 | 0.213 | 3.90 | 0.006 | N.D. | 9 |
| 12 | 0.231 | 2.10 | 0.006 | 1553 | 14 |
| 13 | 0.271 | 2.10 | 0.006 | 1292 | 19 |
| 14 | 0.281 | 1.23 | 0.006 | 791 | 15 |
| 15 | 0.282 | 3.90 | 0.007 | N.D. | 14 |
| 16 | 0.385 | 2.10 | 0.008 | 916 | 32 |
| 17 | 0.496 | 1.23 | 0.009 | 359 | 56 |
| 18 | 0.544 | 2.10 | 0.012 | 607 | 65 |
| 19 | 0.565 | 3.90 | 0.011 | 904 | 58 |
| 20 | 0.593 | 3.90 | 0.013 | 909 | 57 |
| 21 | 0.619 | 5.60 | 0.013 | 1065 | 59 |

TABLE II-A
(Control Fabrics)

| Control Fabric | Cup Crush Energy (grams/mm) | Drape CD (cm) | Drape MD (cm) | Poisson Ratio 10% MD Elongation | Grab Tensile Peak Load (lbs) CD |
|---|---|---|---|---|---|
| Control #1 | 474 | 1.62 | 2.89 | 3.49 | 4.8 |
| Control #2 | 84 | 1.09 | 1.40 | 4.10 | 3.19 |
| Control #3 | 435 | 1.73 | 1.99 | 3.32 | 6.87 |
| Fitessa Control | 453 | 1.60 | 2.00 | 4.82 | 6.1 |
| KAMI Control | 150 | 1.18 | 1.53 | 4.19 | 2.9 |
| Polybond Control | 179 | 1.47 | 1.23 | 2.87 | 6.5 |

TABLE II-B
(Inventive Discontinuous Bonded Fabric)

| Sample of Pattern Bonded | Cup Crush Energy (grams/mm) | Drape CD (cm) | Drape MD (cm) | Poisson Ratio 10% MD Elongation | Grab Tensile Peak Load (lbs) CD |
|---|---|---|---|---|---|
| 1 | 909 | 2.12 | 2.77 | 2.82 | 4.88 |
| 2 | 347 | 1.58 | 2.59 | 3.18 | 2.92 |
| 3 | 114 | 1.38 | 2.13 | 3.81 | 1.82 |
| 4 | N.D. | 1.44 | 1.82 | 4.15 | 0.88 |
| 5 | N.D. | 1.82 | 2.19 | 4.13 | 1.00 |
| 6 | 53 | 1.56 | 1.91 | 4.04 | 1.44 |
| 7 | 216 | 1.44 | 1.98 | 3.36 | 2.34 |
| 8 | 522 | 2.22 | 2.25 | 2.72 | 4.15 |

TABLE II-C
(Inventive Pattern-Unbonded Fabrics #1 & #2)

| Sample of Pattern Unbonded | Cup Crush Energy (grams/mm) | Drape CD (cm) | Drape MD (cm) | Poisson Ratio 10% MD Elongation | Grab Tensile Peak Load (lbs) CD |
|---|---|---|---|---|---|
| 9 | 48 | 1.00 | 1.79 | 4.47 | 1.0 |
| 10 | 149 | 1.38 | 1.73 | 4.26 | 2.3 |
| 11 | 152 | 1.47 | 1.83 | 4.34 | 0.5 |
| 12 | 233 | 1.31 | 2.05 | 3.75 | 3.1 |
| 13 | 344 | 1.45 | 2.23 | 3.61 | 3.2 |
| 14 | 282 | 1.37 | 2.30 | 3.29 | 2.7 |
| 15 | 279 | 1.64 | 2.30 | 4.04 | 1.7 |
| 16 | 591 | 2.47 | 2.47 | 3.08 | 3.9 |
| 17 | 1049 | 1.93 | 2.61 | 2.49 | 5.9 |
| 18 | 1238 | 1.89 | 3.02 | 2.53 | 7.1 |
| 19 | 1126 | 1.73 | 2.94 | 3.05 | 5.7 |
| 20 | 1104 | 2.11 | 2.61 | 2.85 | 5.2 |
| 21 | 1066 | 2.15 | 2.33 | 3.05 | 3.6 |

TABLE III-A
(Control Fabrics)

| Control Fabric | Grab Tensile Peak Strain (%) CD | Grab Tensile Peak Energy CD | Grab Tensile Peak Load (lbs) MD | Grab Tensile Peak Strain (%) MD |
|---|---|---|---|---|
| Control #1 | 79.1 | 5.7 | 7.4 | 45.3 |
| Control #2 | 120.96 | 5.77 | 5.59 | 74.68 |
| Control #3 | 76.84 | 9.42 | 9.02 | 68.01 |
| Fitessa Control | 59.7 | | 6.5 | 28.2 |
| KAMI Control | 44.1 | | 6.2 | 34.8 |
| Polybond Control | 80.4 | | 10.5 | 70.9 |

TABLE III-B
(Inventive Discontinuous Bonded Fabric)

| Sample of Pattern Bonded | Grab Tensile Peak Strain (%) CD | Grab Tensile Peak Energy CD | Grab Tensile Peak Load (lbs) MD | Grab Tensile Peak Strain (%) MD |
|---|---|---|---|---|
| 1 | 36.06 | 2.98 | 6.63 | 22.19 |
| 2 | 33.87 | 1.64 | 3.64 | 16.07 |
| 3 | 36.38 | 1.07 | 2.05 | 13.07 |
| 4 | 31.85 | 0.44 | 1.50 | 16.83 |
| 5 | 52.56 | 0.79 | 1.60 | 12.38 |
| 6 | 27.45 | 0.65 | 1.50 | 12.36 |
| 7 | 28.59 | 1.10 | 2.79 | 14.95 |
| 8 | 32.02 | 2.25 | 3.93 | 15.54 |

TABLE III-C
(Inventive Pattern-Unbonded Fabric #1 and #2)

| Sample of Pattern Unbonded | Grab Tensile Peak Strain (%) CD | Grab Tensile Peak Energy CD | Grab Tensile Peak Load (lbs) MD | Grab Tensile Peak Strain (%) MD |
|---|---|---|---|---|
| 9 | 58.2 | 0.9 | 2.0 | 28.6 |
| 10 | 66.9 | 3.2 | 3.4 | 29.6 |
| 11 | 74.7 | 0.7 | 1.9 | 64.5 |
| 12 | 56.5 | 2.6 | 4.4 | 32.9 |
| 13 | 40.7 | 2.1 | 4.4 | 27.0 |
| 14 | 34.3 | 1.6 | 5.8 | 28.3 |
| 15 | 69.0 | 2.4 | 3.5 | 44.6 |
| 16 | 32.5 | 2.0 | 7.0 | 29.9 |
| 17 | 28.7 | 3.0 | 10.9 | 25.5 |
| 18 | 39.8 | 4.5 | 10.3 | 24.7 |
| 19 | 44.3 | 4.3 | 9.2 | 30.2 |
| 20 | 66.6 | 7.1 | 9.2 | 35.1 |
| 21 | 63.8 | 5.1 | 7.1 | 34.2 |

TABLE IV-A
(Control Fabrics)

| Control Fabric | Grab Tensile Peak Energy MD | Strip Tensile Peak Load (lbs) CD | Strip Tensile Peak Strain (%) CD |
|---|---|---|---|
| Control #1 | 6.1 | | |
| Control #2 | 7.45 | 2.63 | 92.53 |
| Control #3 | 11.17 | 5.79 | 45.93 |
| Fitessa Control | | | |
| KAMI Control | | | |
| Polybond Control | | 2.5 | 89.8 |

TABLE IV-B
(Inventive Discontinuous Bonded Fabric)

| Sample of Pattern Bonded | Grab Tensile Peak Energy MD | Strip Tensile Peak Load (lbs) CD | Strip Tensile Peak Strain (%) CD |
|---|---|---|---|
| 1 | 2.75 | 5.45 | 30.25 |
| 2 | 1.08 | 3.65 | 29.58 |
| 3 | 0.51 | 1.97 | 27.82 |
| 4 | 0.47 | 1.27 | 28.50 |
| 5 | 0.37 | 0.90 | 41.51 |
| 6 | 0.35 | 1.85 | 20.85 |
| 7 | 0.77 | 3.16 | 23.35 |
| 8 | 1.12 | 4.55 | 23.20 |

TABLE IV-C
(Inventive Pattern-Unbonded Fabrics #1 & #2)

| Sample of Pattern Unbonded | Grab Tensile Peak Energy MD |
|---|---|
| 9 | 1.1 |
| 10 | 1.7 |
| 11 | 2.5 |
| 12 | 2.6 |
| 13 | 1.9 |
| 14 | 3.0 |
| 15 | 3.3 |
| 16 | 3.5 |
| 17 | 5.1 |
| 18 | 4.7 |
| 19 | 5.2 |
| 20 | 6.0 |
| 21 | 4.7 |

Figures 7 through 11 illustrate in graph form the data compiled in the tables. In accordance with the present invention, the Poisson Ratio of both the pattern bonded ultralight material 5 presented in TABLE II-B and the pattern unbonded material 4 (Figures 1 and 2) presented in TABLE II-C, is lower than the controls presented in TABLE II-A. The Poisson Ratio is lower across the range of basis weights for all fiber deniers. Thus, the fabrics of the present invention have superior dimensional stability to the control fabrics. The tables illustrate the effect of denier on the Poisson Ratio. The fabrics of the present invention outperform the controls at similar basis weights, even when the deniers are large for the fabrics of the present invention.

Normally, with typical fabrics, as the basis weight of the fabric decreases, at a constant denier per filament, the Poisson Ratio would increase. This increase would be expected because there are fewer fibers per unit of area of the fabric. Normally, with typical fabrics, as the denier per filament decreases at a constant basis weight, the Poisson Ratio would also decrease. This would result because there would be more fibers per unit of area. One way to correct a poor Poisson Ratio at a fixed basis weight, would be to lower the denier per filament. However, in some instances leeway in lowering the denier per filament is not available to the web designer because of other factors controlled by the denier. For example, reduction in denier also reduces permeability, or porosity, which could be undesirable for certain applications, such as the liner of personal care products or the facings of an absorbent wiping laminate where liquid intake objectives are better met with higher permeabilities. Surprisingly, the fabrics of the present invention with large denier per filament, outperform the control fabrics, at equal basis weights, even though the controls have a lower denier per filament than

the fabrics of the invention. The conclusion drawn from this fact is that not only are the inventive fabrics providing an improved dimensional stability at low basis weights, these inventive fabrics also outperform comparable fabrics that have a lower denier per filament with an optimized dimensional stability.

The following Table V illustrates in summary form the results of the Poisson Ratios of various fabrics with basis weights of less than 0.40 osy. The fabrics for which the following data was provided are those fabrics that exhibited the lowest Poisson Ratios at a particular Bonding Temperature. The Bonding Temperatures are the surface temperatures of both the pattern and anvil rolls when only one temperature is given; when two temperatures are listed, the first number indicates the temperature of the pattern roll surface and the second number indicates the temperature of the anvil roll surface. In addition, Table V illustrates the product obtained by multiplying the basis weight of the fabrics by the Poisson Ratios. The entries in Table V are arranged in order of increasing of such factors.

TABLE V

| Web Sample (PU or DB) | Basis Weight (oz/yd$^2$) | Denier (dpf) | Poisson Ratio 10% MD Elongation | (Poisson Ratio) x (Basis Weight) (osy•PR) | Bonding Temperature (°F) |
|---|---|---|---|---|---|
| 9 (PU) | 0.119 | 1.23 | 4.47 | 0.53 | 285 |
| 4 (DB) | 0.157 | 1.10 | 4.15 | 0.65 | 289/286 |
| 5 (DB) | 0.181 | 1.40 | 4.13 | 0.75 | 289/286 |
| 10 (PU) | 0.189 | 2.10 | 4.26 | 0.80 | 290 |
| 6 (DB) | 0.212 | 1.40 | 4.04 | 0.86 | 289/286 |
| 12 (PU) | 0.231 | 2.10 | 3.75 | 0.87 | 290 |
| 3 (DB) | 0.233 | 1.10 | 3.81 | 0.89 | 289/286 |
| 11 (PU) | 0.213 | 3.90 | 4.34 | 0.92 | 275 |
| 14 (PU) | 0.281 | 1.23 | 3.29 | 0.92 | 290 |
| 13 (PU) | 0.271 | 2.10 | 3.61 | 0.98 | 290 |
| 7 (DB) | 0.306 | 1.40 | 3.36 | 1.03 | 289/286 |
| 2 (DB) | 0.327 | 1.10 | 3.18 | 1.04 | 289/286 |
| 15 (PU) | 0.282 | 3.90 | 4.04 | 1.14 | 275 |
| 16 (PU) | 0.385 | 2.10 | 3.08 | 1.19 | 290 |
| KAMI (DB) | 0.29 | 2.90 | 4.19 | 1.22 | N.D. |
| Control #2 (DB) | 0.30 | 1.86 | 4.10 | 1.23 | 280/275 |

The present invention may be quantitatively defined by employing a factor arrived at by multiplying the basis weight of the nonwoven times the Poisson Ratio at 10% elongation in the machine direction. This factor may be expressed in osy•PR where "PR" stands for the Poisson Ratio. The present inventive nonwoven webs, whether high density discontinuous bonded fabrics or pattern-unbonded fabrics, will exhibit such a factor of equal to or less than 1.20 osy•PR.

Although a preferred embodiment of the invention has been described using specific terms, devices and methods, such description is for illustrative purposes only. The words used are words of description rather than of limitation. It is to be understood that changes and variations may be made by those of ordinary skill in the art without departing from the spirit and scope of the present invention, which is set forth in the following claims. In addition, it should be understood that aspects of the various embodiments may be interchanged, both in whole or in part.

**WHAT IS CLAIMED IS:**

1. An ultra lightweight, dimensionally stable, nonwoven fabric comprising:

a nonwoven web of fibers or filaments;

said nonwoven web having a basis weight of less than 0.40 osy and having on a surface thereof a pattern of bonded areas;

said nonwoven web having a dimensional stability characterized by a factor calculated by multiplying the nonwoven web's Poisson Ratio at 10% elongation in the machine direction by the nonwoven web's basis weight, wherein said factor is equal to or less than 1.20 osy•PR.

2. The fabric of claim 1, wherein said pattern of bonded areas is continuous.

3. The fabric of claim 1 wherein said nonwoven web has a basis weight of less than about .30 osy.

4. The fabric of claim 1 wherein said nonwoven web has a basis weight of less than about .20 osy.

5. The fabric of claim 1 wherein said bonded areas comprise about 50% or less of the total area of said surface.

6. The fabric of claim 1 wherein said bonded areas comprise about 40% or less of the total area of said surface.

7. The fabric of claim 1 wherein said bonded areas comprise about 30% of the total area of said surface.

8. The fabric of claim 1 wherein said bonded areas comprise about 15% of the total area of said surface.

9. The fabric of claim 1 wherein said pattern of bonded areas comprises a plurality of discontinuous point bonds.

10. The fabric of claim 9 wherein said bonded areas result in a web having a point bond density of at least about 400 pin bonds per square inch.

11. The fabric of claim 1 wherein said nonwoven web comprises meltblown filaments.

12. The fabric of claim 1 wherein said nonwoven web comprises spunbond fibers.

13. The fabric of claim 1 wherein said nonwoven web comprises multicomponent filaments.

14. The fabric of claim 1 wherein said nonwoven web comprises thermoplastic fibers.

15. The fabric of claim 1 wherein said nonwoven web comprises polypropylene fibers.

16. A personal care product comprising the fabric of claim 1 as a facing therein.

17. The personal care product of claim 16 wherein said nonwoven web comprises spunbonded polyolefin fibers.

18. The personal care product of claim 16 wherein said personal care product is an adult incontinence product.

19. The personal care product of claim 16 wherein said personal care product is a feminine hygiene product.

20. The personal care product of claim 16 wherein said personal care product is a diaper.

21. An ultra lightweight, dimensionally stable, nonwoven fabric comprising:

a nonwoven web of fibers or filaments;

said nonwoven web having a basis weight of less than 0.40 osy and having on a surface thereof and having on a surface thereof a pattern of continuously bonded areas;

said nonwoven web having a dimensional stability characterized by a factor calculated by multiplying the nonwoven web's Poisson Ratio at 10% elongation in the machine direction by the nonwoven web's basis

weight, wherein said factor is equal to or less than 1.20 osy•PR.

22. An ultra lightweight, dimensionally stable, nonwoven fabric comprising:

a nonwoven web of fibers or filaments;

said nonwoven web having a basis weight of less than 0.40 osy and having on a surface thereof and having on a surface thereof a pattern of discontinuously bonded areas;

said nonwoven web having a dimensional stability characterized by a factor calculated by multiplying the nonwoven web's Poisson Ratio at 10% elongation in the machine direction by the nonwoven web's basis weight, wherein said factor is equal to or less than 1.20 osy•PR.

23. A method for producing an ultra lightweight nonwoven fabric comprising:

providing a nonwoven web having a fibrous structure of unbonded individual fibers or filaments with a basis weight of less than 0.40 osy; and

creating on a surface of said nonwoven web, a pattern of bonded areas yielding a dimensional stability characterized by a factor calculated by multiplying the nonwoven web's Poisson Ratio at 10% elongation in the machine direction by the nonwoven web's basis weight, wherein said factor is equal to or less than 1.20 osy•PR.

24. The method of claim 23 wherein the pattern of bonded areas created on said surface of said nonwoven web is continuous.

25. The method of claim 23 wherein the pattern of bonded areas created on said surface of said nonwoven web is discontinuous.

26. The method of claim 25 wherein said pattern of bonded areas created on said surface of said nonwoven web results in a web having a bond density of at least about 400 point bonds per square inch.

27. The method of claim 23 wherein a roll with a plurality of

recesses therein is used to create said pattern of bonded areas on said surface of said nonwoven web.

28. The method of claim 23 wherein a roll with a plurality of raised projections therein is used to create said pattern of bonded areas on said surface of said nonwoven web.

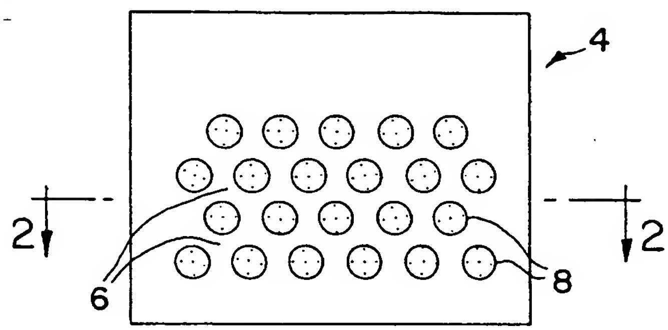


FIG. 1

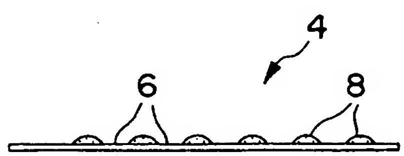


FIG. 2

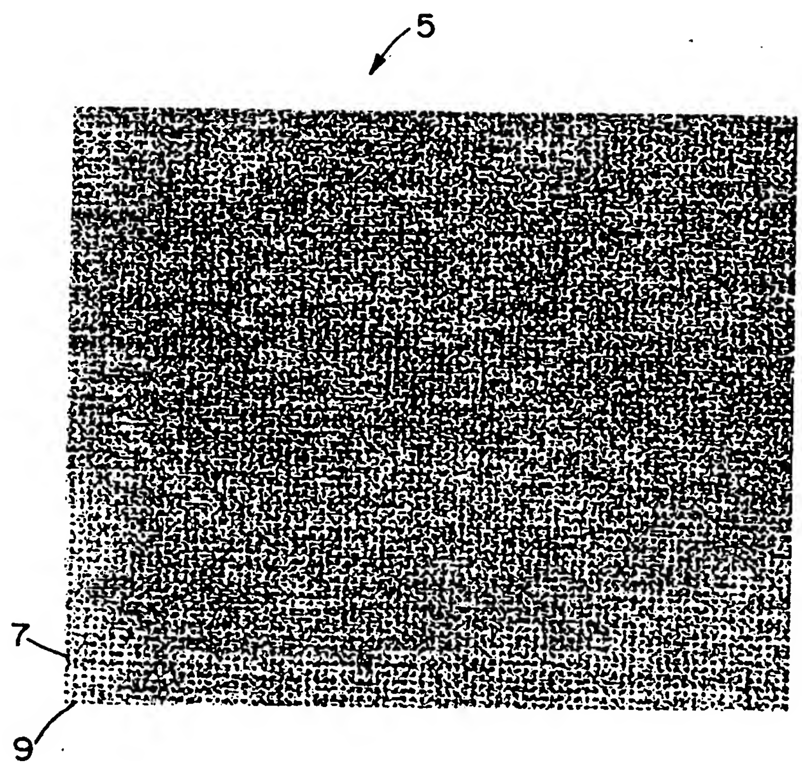


FIG. 3

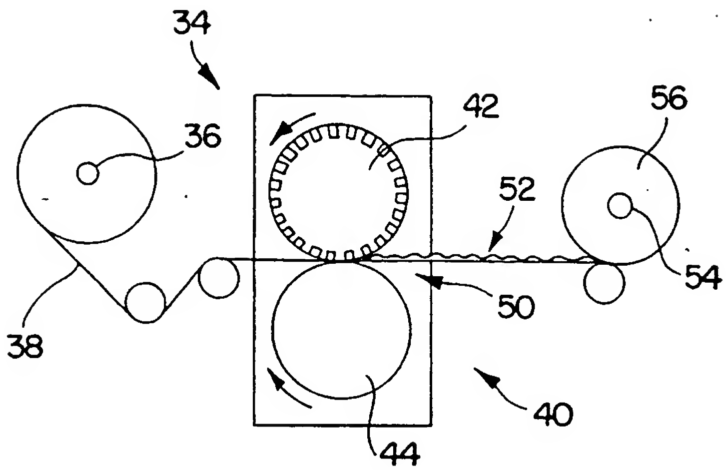


FIG. 4

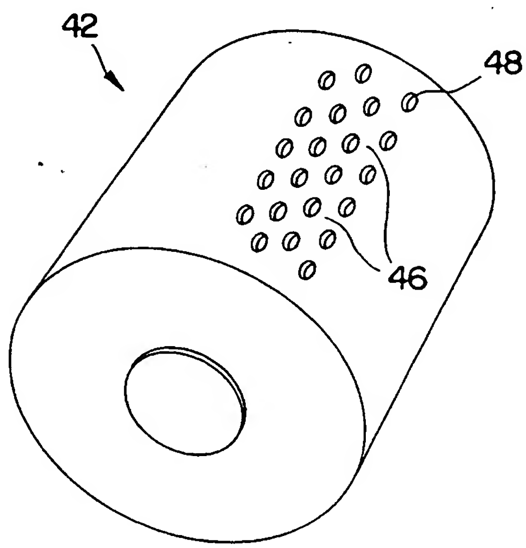


FIG. 5

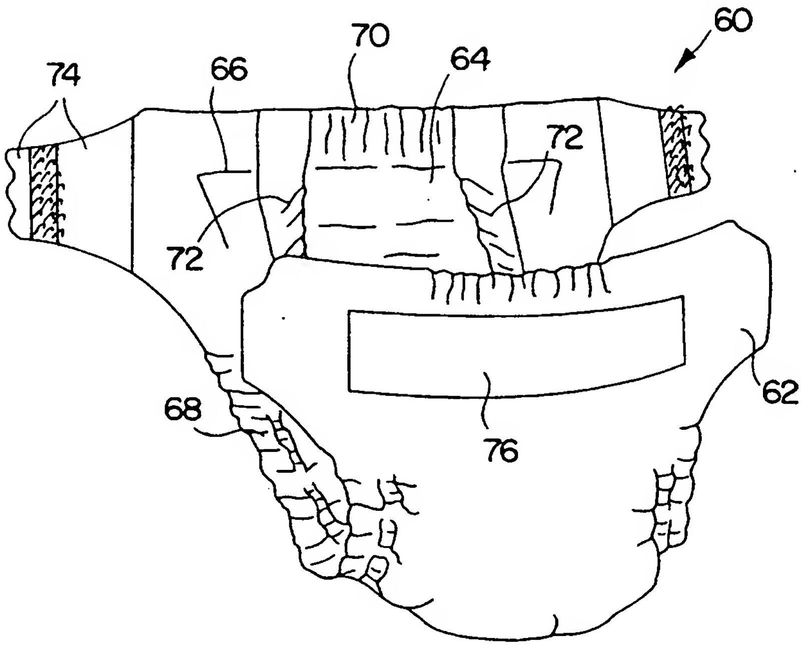


FIG. 6

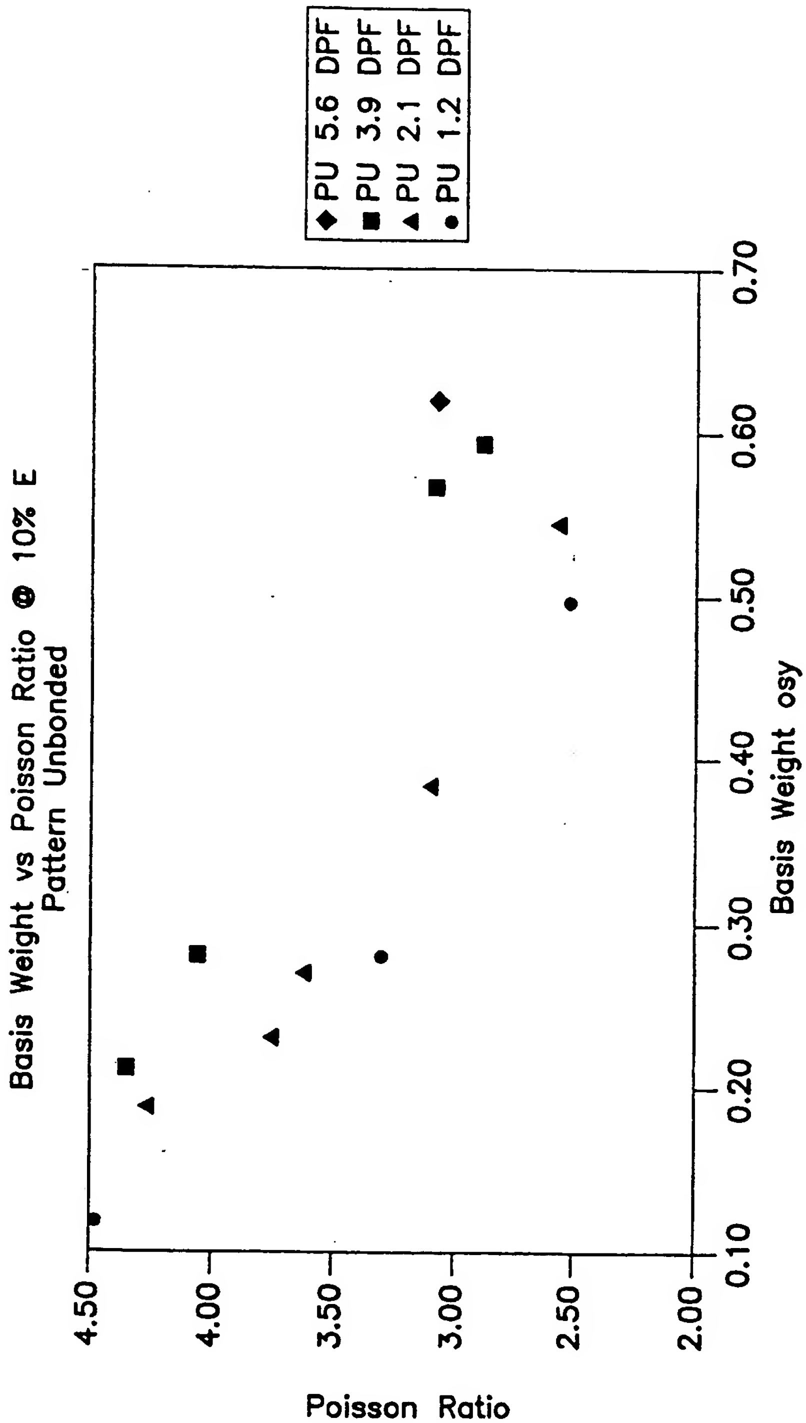
Basis Weight vs Poisson Ratio @ 10% E
Pattern Unbonded
◆ PU 5.6 DPF
■ PU 3.9 DPF
▲ PU 2.1 DPF
● PU 1.2 DPF
Poisson Ratio
4.50
4.00
3.50
3.00
2.50
2.00
Basis Weight osy
0.10
0.20
0.30
0.40
0.50
0.60
0.70

FIG. 7

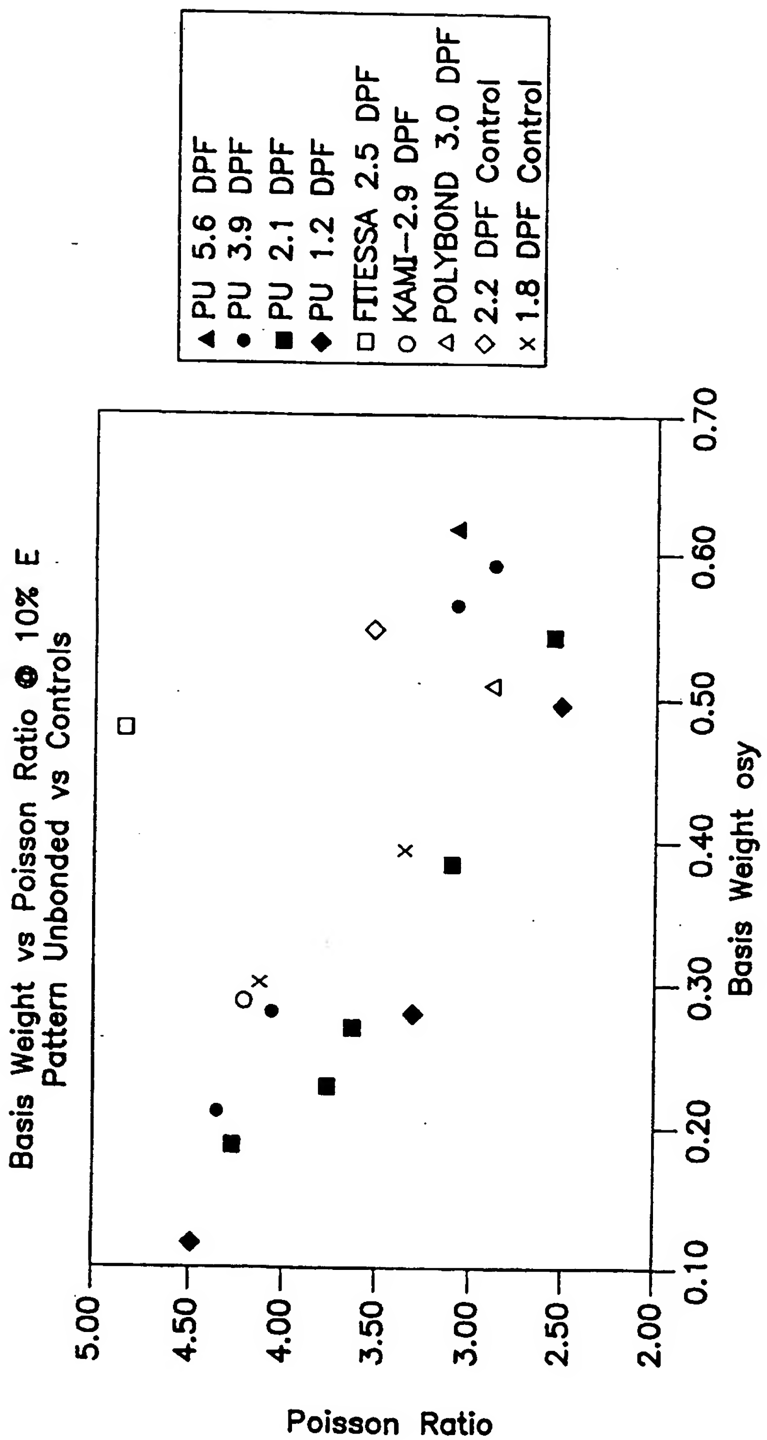
Basis Weight vs Poisson Ratio @ 10% E
Pattern Unbonded vs Controls
▲ PU 5.6 DPF
● PU 3.9 DPF
■ PU 2.1 DPF
◆ PU 1.2 DPF
□ FITESSA 2.5 DPF
○ KAMI-2.9 DPF
△ POLYBOND 3.0 DPF
◇ 2.2 DPF Control
× 1.8 DPF Control
5.00
4.50
4.00
3.50
3.00
2.50
2.00
Poisson Ratio
0.10
0.20
0.30
0.40
0.50
0.60
0.70
Basis Weight osy

FIG. 8

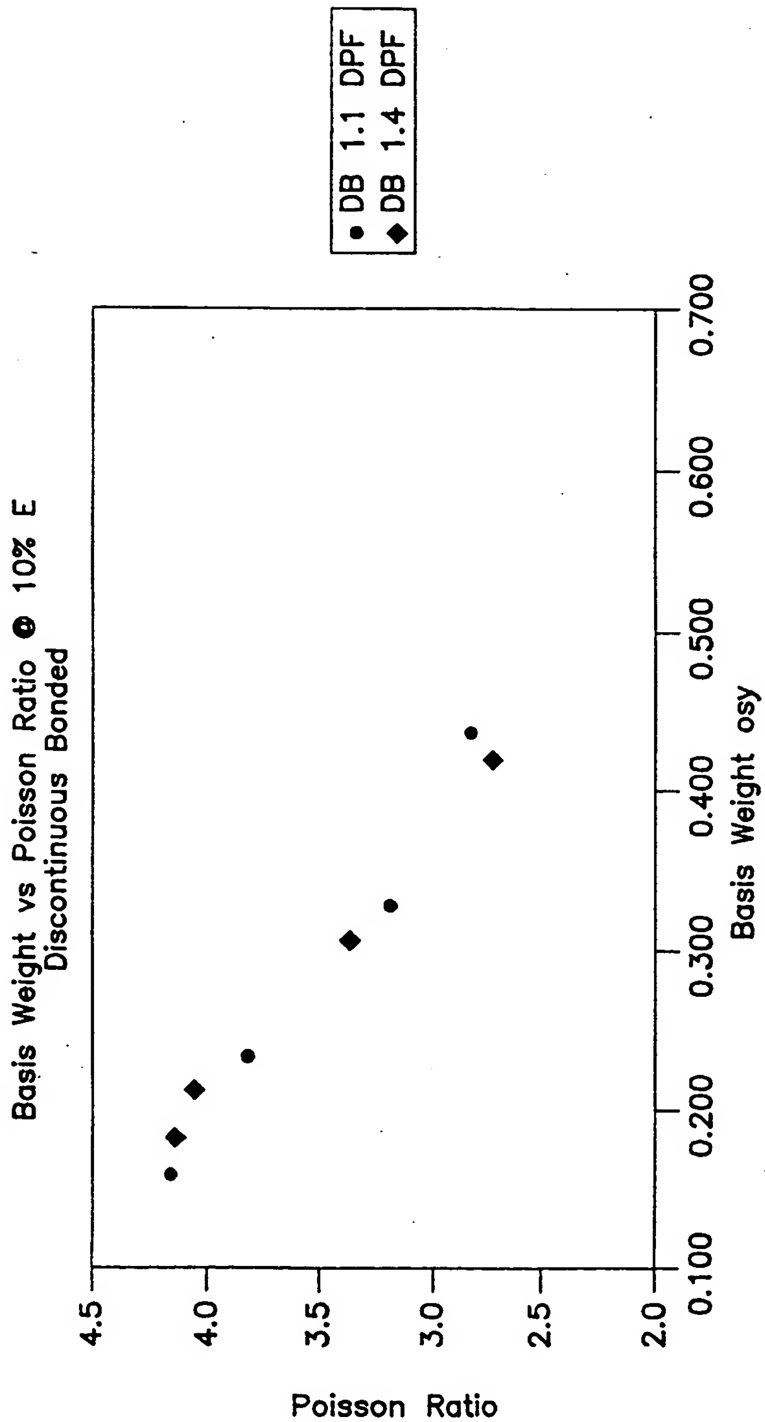
Basis Weight vs Poisson Ratio @ 10% E
Discontinuous Bonded
DB 1.1 DPF
DB 1.4 DPF
Poisson Ratio
4.5
4.0
3.5
3.0
2.5
2.0
Basis Weight osy
0.100
0.200
0.300
0.400
0.500
0.600
0.700

FIG. 9

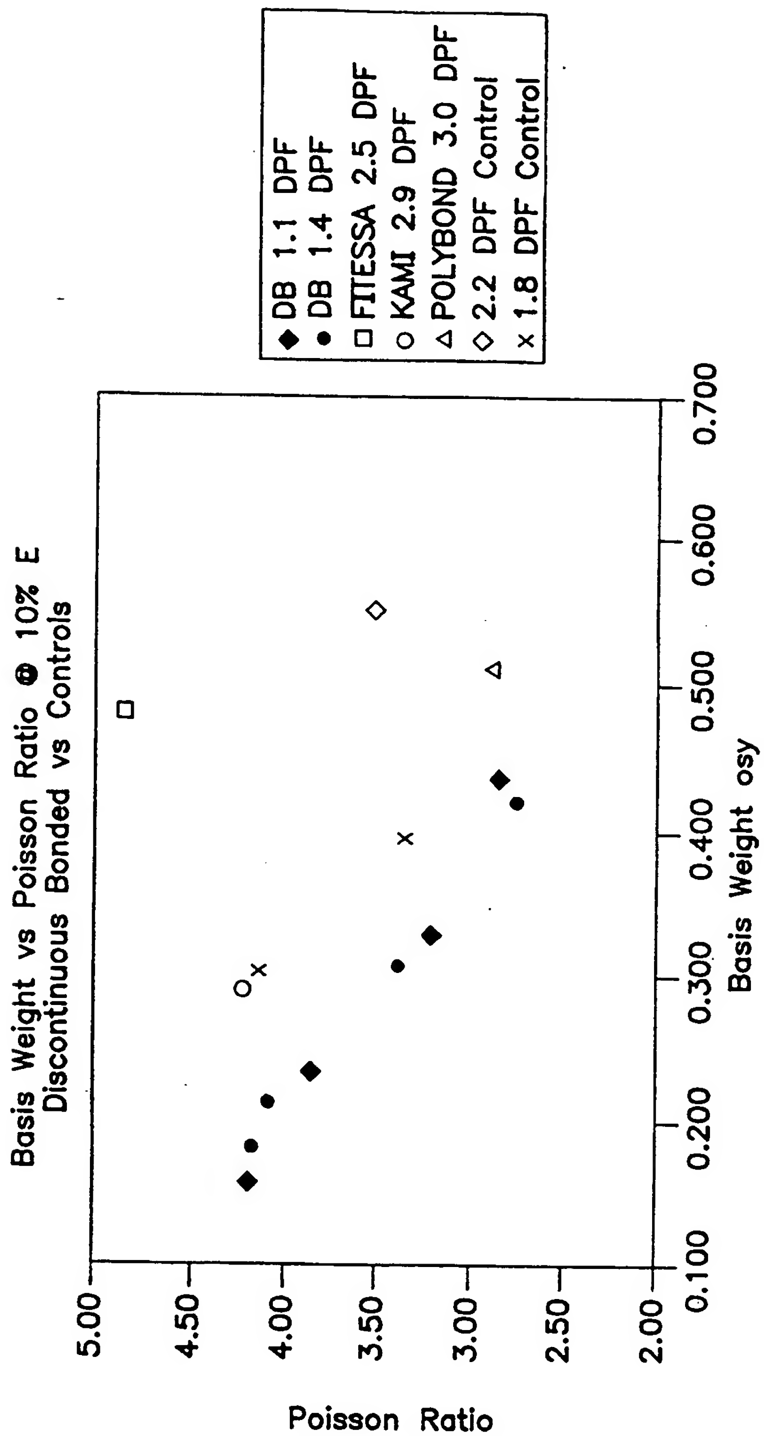
Basis Weight vs Poisson Ratio @ 10% E
Discontinuous Bonded vs Controls
◆ DB 1.1 DPF
● DB 1.4 DPF
□ FITESSA 2.5 DPF
○ KAMI 2.9 DPF
△ POLYBOND 3.0 DPF
◇ 2.2 DPF Control
× 1.8 DPF Control
5.00
4.50
4.00
3.50
3.00
2.50
2.00
Poisson Ratio
0.100
0.200
0.300
0.400
0.500
0.600
0.700
Basis Weight osy

FIG. 10

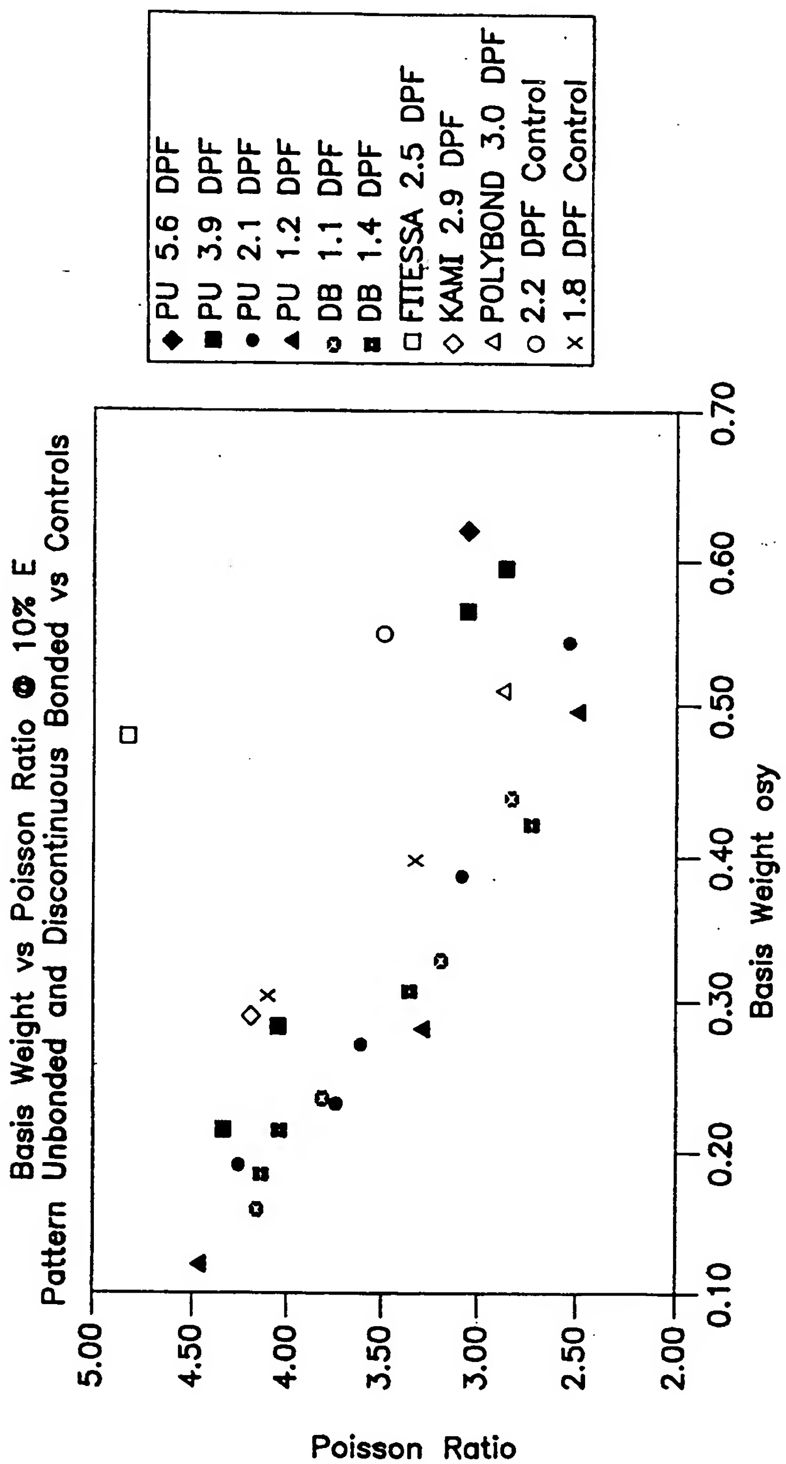
Basis Weight vs Poisson Ratio @ 10% E
Pattern Unbonded and Discontinuous Bonded vs Controls
PU 5.6 DPF
PU 3.9 DPF
PU 2.1 DPF
PU 1.2 DPF
DB 1.1 DPF
DB 1.4 DPF
FITESSA 2.5 DPF
KAMI 2.9 DPF
POLYBOND 3.0 DPF
2.2 DPF Control
1.8 DPF Control
5.00
4.50
4.00
3.50
3.00
2.50
2.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
Basis Weight osy
Poisson Ratio

FIG. 11

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/26843

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 6 D04H1/54 A61F13/15 D04H13/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 D04H A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | CA 2 099 846 A (KIMBERLY CLARK CO) 1 July 1994<br>see page 4, line 4 - page 5, line 10<br>see page 15, line 12 - line 24<br>see example 1 | 1-28 |
| A | WO 97 24482 A (KIMBELY CLARK CORP) 10 July 1997<br>see the whole document | 1-28 |
| A | US 5 424 115 A (STOKES TY J) 13 June 1995<br>see the whole document | 1-28 |
| A | US 3 949 128 A (OSTERMEIER KURT W) 6 April 1976<br>see claim 6 | 1-28 |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Information on patent family members

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